Jet Propulsion Laboratory
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NASA Detector Update

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to the ESA Euclid Science Team

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MPIA Heidelberg

Euclid NIR detector characterization at JPL Precision Projector Laboratory

Progress Report 2017-03-13

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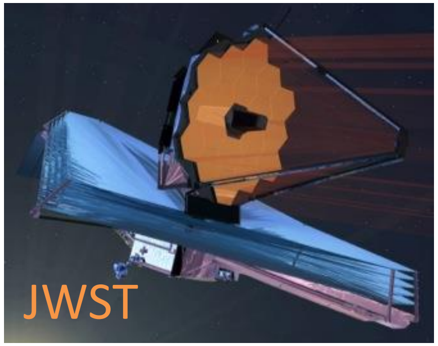
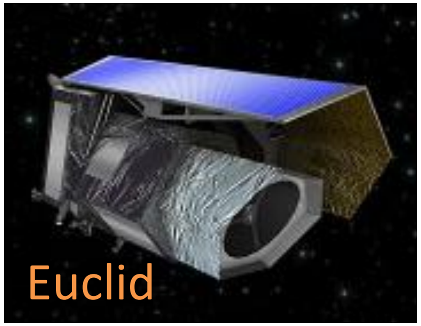
Objective: Study H2RG sub-pixel response

- Engineering grade H2RG (#18546) was lent to JPL to investigate nature of the cross-hatch pattern seen in flat-field images.
- Pattern is visible even under an optical microscope.
- Concern: this may correspond to sub-pixel variations in quantum efficiency (QE) or charge redistribution, making photometric calibration difficult.
- By emulating Euclid-like point sources, we can measure the nature of this pattern and what effect it has on photometry

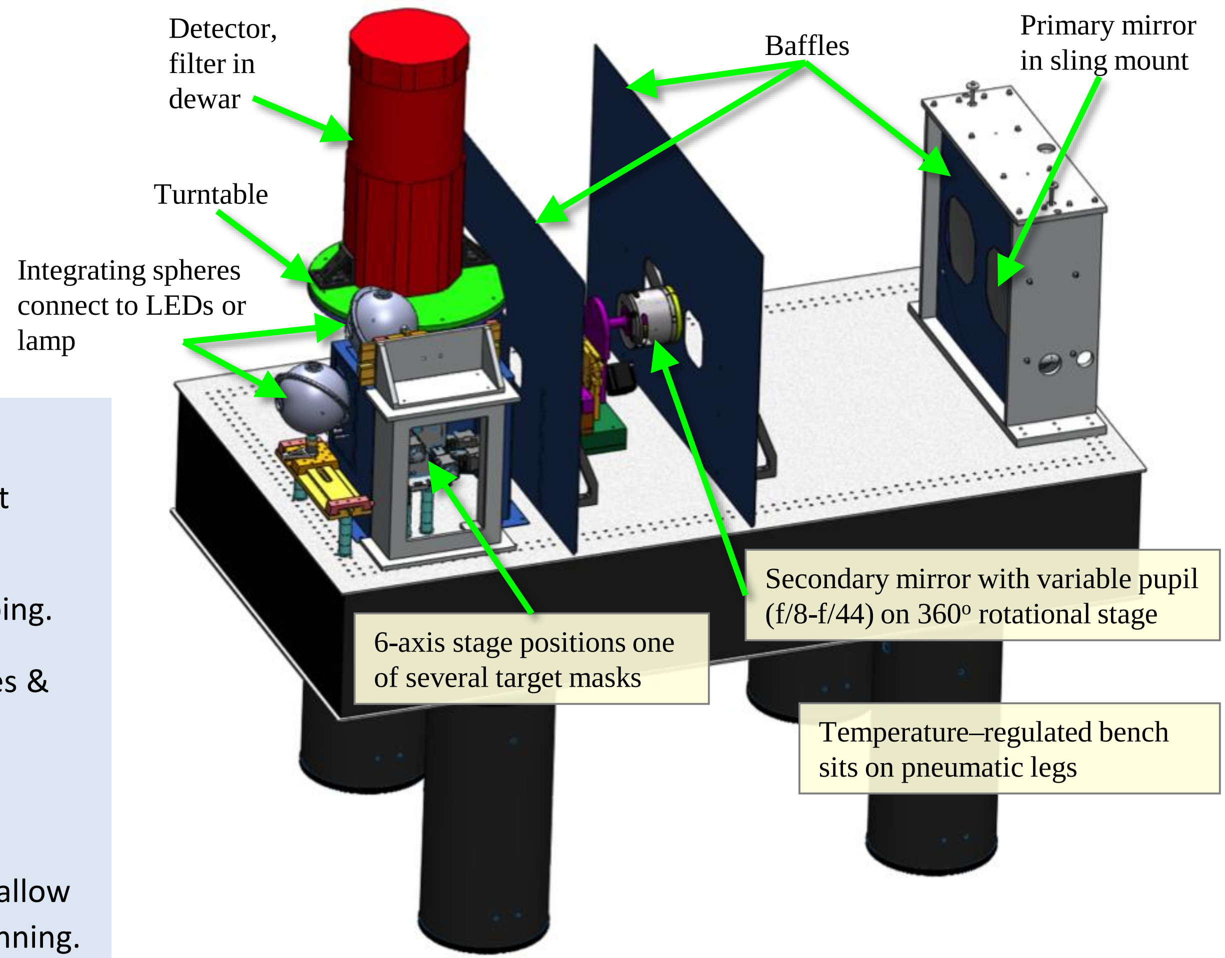
The Precision Projector Laboratory



- Since its inception in 2008, the **chief design goal** of PPL has been the emulation of weak gravitational lensing survey data for WFIRST (formerly JDEM, SNAP).
- PPL emulates the WFIRST f number but **not** the optics – the simplest possible PSF is used to reduce optical effects and uncover detector systematics
- PPL is versatile and can rapidly generate a range of signals: stars, galaxies, spectra, flat fields / backgrounds, focal ratios, filters, image motion
- PPL has readily enabled detector tests for other missions
  - Photometric stability for exoplanet transits with JWST
  - Wavefront correction camera test for Keck
  - Emulation of fiber position measurements for Subaru/PFS
  - Intra-pixel response measurement for Euclid
- **PPL group includes experts on detector operation, optical engineering, weak gravitational lensing analysis, and cosmology.**



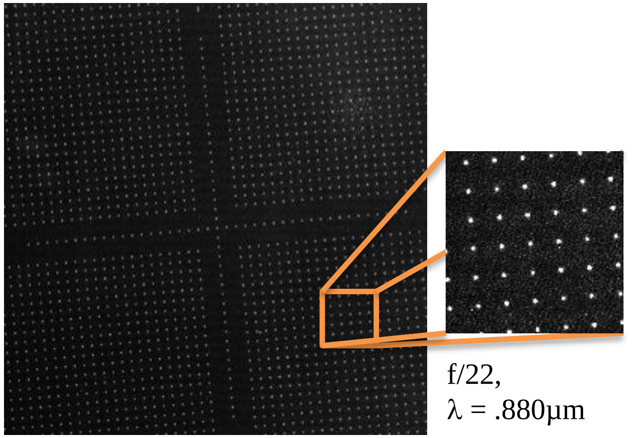
Precision Projector Laboratory testbed



Projector System Features:

- Diffraction-limited optics with simple point spread function (PSF).
- High image stability through passive damping.
- Custom image masks, adjustable f/#, stages & illumination provide a range of signals for investigating various detector effects and mission conditions.
- Servo controls on mask and tip-tilt mirror allow fine image positioning for dithering or scanning.
- IMage COMbination algorithm implements WFIRST image reconstruction strategy with dithered, undersampled images.
- Dedicated 144 core cluster allows near real-time analysis of 1000’s of images.
- Dewar customized for **HxRG + SIDECAR**

Image of 3µm spot grid (emulated stars)



Interpretation

- No significant effect on photometric stability in the good detector region. Scatter in the cross-hatched region increases by 1.5% relative to mean. Flat fielding reduces this to 1%.

- This is consistent with sub-pixel QE variations along the scan (column) direction. If the cross-hatch pattern were due to charge redistribution, we expect no effect in the uncorrected images

- We have not eliminated all systematics but the correlation of the increased scatter with the cross-hatch pattern is compelling.

- **Averaging over a large detector area may be hiding small-scale effects in the "good" region.**

Ways to learn more

- Repeat experiment with aperture set to different f#. Effect should decrease with larger f/#.
- Repeat with increased signal to noise, average over smaller detector regions.
- Try different scanning patterns
- Map out photometry variations (may need to be more careful about persistence)
- Oversample the spots (point spread functions) through dithering and reconstruct sub-pixel QE from its distortions to the PSF.

Extra Slides

Detector Delivery

- NASA preship review March 21, 2017 (successful)
- Delivery of first 3 SCS flight units (pending positive outcome of review): TODAY!
- Final SCS delivery estimated November, 2017

Euclid

NASA Euclid Science
Input to Hardware Delivery

Michael Seiffert

NASA Euclid Project Scientist

SCA Selection

We have used a figure-of-merit (FoM) approach for SCA selection.

- **Assigns a scalar number to each Euclid NIR flight candidate detector**
  - 0 represents a dead detector and 1 represents an ideal, perfect detector
  - The FoM represents the scientific performance of the detector in the Euclid Survey
- **The FoM is calculated on a per detector basis. No inclusion of how detectors complement one another in the focal plane.**
- **NASA and EC FoM codes cross-checked for consistency.**
- **For the first 4 SCAs, we have calculated a number of variants on the FoM. The first 4 SCAs are in the top 12 in ranking in any permutation of these FoMs.**
- **Results discussed with ESA and the EC. The underlying detector data has been shared with ESA and the EC.**
- **Choosing the first 8 or so SCAs is straightforward – there will be more discussion on the last 4!**

Recent Developments

Results of SCS flight testing consistent with expectations from SCA testing, with one exception.

- **The key drivers, Noise and QE, are consistent**
- **Image persistence is a “goal” not a requirement. SCS’s performance exceeds goal.**

Summary

- *Good* and *close* working relationship with ESA and the EC.

- First 4 SCAs were selected for flight integration.

- SCS scientific performance exceeds requirements.